Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

the equation $y = mx^n$, the light being proportional to some power of the sun's angular distance.

The most noticeable deviation from a straight line is in the curve for series I. where it approaches the axis of $y$; here the intensities are less than required by a straight line, which is explained by the fact that this series was made late in the afternoon of a winter day when the light of the sun itself was rapidly diminishing, and, as before stated, the observations nearest the sun were made last.

Neglecting, for the reason just given, the first three observations of series I., we obtain the following as the most probable values of $n$ in each case: series I. —1.4; II. — 1.4; III. — 1.32; IV. — 1.21. Computing now the numerical value of $m$ for each series, and substituting in the equation $y = mx^n$, we have for series: I. $y = 359x^{-1.4}$; II. $y = 33.1x^{-1.4}$; III. $y = 13.7x^{-1.32}$; IV. $y = 12.6x^{-1.21}$.

Columns 1, 2, 3, and 4 give the deviations from the formulæ of the observations of series I., II., III., and IV. respectively; the deviations being expressed in percentages of the intensities. The last column gives the mean of the deviations; neglecting, as before, the first three observations of series I. Although some of the deviations are quite large, yet the sums of the positive and negative deviations are approximately equal; and it will be observed that they frequently change their sign, which shows a close agreement with theory. It is probable that the larger deviations are attributable in part, at least, to sudden changes in the reflecting power of the sky, such as would be produced by air currents or by the precipitation or dissipation of atmospheric moisture.

That these deviations are greater than those due to errors of observation, is clearly shown by the experiments in the preceding article.

## V.—LIGHT ABSORBED BY THE ATMOSPHERE OF THE SUN.

By E. C. Pickering and D. P. Strange.

The following series of experiments were made for the purpose of determining the relative amount of light received from portions of the sun's surface at varying distances from the centre of its disk. For this purpose, the sun's rays were reflected into a darkened room by means of the black glass mirror of a porte-lumière, and an image of the sun, 40 cms. in diameter, was, by means of a small telescope, thrown upon a screen placed at a distance of 230 cms. from the aperture. In the centre of this screen was cut a circular hole 2 cms. in diameter, and the light passing through this aperture was received upon a Bunsen's photometer disk, placed at a distance of 25 cms. behind it. The porte-lumière was then moved until the desired portion of the image coincided with the centre of the aperture in the screen, and the image kept at rest by a slight movement of the telescope whilst the photometer reading was taken. The light used for comparison was a standard candle, which was placed in the photometer described above (page 421). Much difficulty was experienced on account of the difference in color of the light from the sun and candle, in obtaining a satisfactory disappearance of the spot of the photometer disk. Various attempts were made to remedy this trouble, by using colored paper, disks of colored plaster, &c., none of which succeeded very well, and the ordinary white disk was finally adopted. A large number of preliminary series of observations were made, and rejected as not being sufficiently accurate.

The results of the last three days' observations are given in Table I.; the first column giving the percentage distance from the centre towards the edge, and the succeeding ones the intensity of the light compared with that of the centre taken as unity. The second column gives the mean of the first day's, the third of the second day's, and the fourth of the third day's observations. Upon the second day, there were several times as many observations taken as upon either of the others, and its mean is correspondingly more reliable. A portion of the observations were taken upon or near the polar, and others upon or near the equatorial, diameter of the sun. Column 5 gives the mean of the measurements taken upon the equatorial, and number 6 the mean upon the polar, diameter. As these are the results of but a

TABLE I.

| | 1st D. | 2d D. | 3d D. | E. | P. | M. | P. Er. | Theor. | Diff. |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 0.0 | 100.0 | 0.0 |
| 12.5 | 98.5 | 98.9 | 99.1 | 99.0 | 98.9 | 98.9 | 0.1 | 99.4 | −0.5 |
| 25. | 94.3 | 97.5 | 94.4 | 97.2 | 97.0 | 96.7 | 0.4 | 97.9 | −1.2 |
| 37.5 | 93.9 | 94.7 | 91.0 | 93.7 | 93.1 | 94.2 | 0.3 | 95.0 | −0.8 |
| 50. | 90.9 | 91.7 | 88.6 | 90.8 | 89.5 | 91.3 | 0.3 | 91.0 | +0.3 |
| 62.5 | 84.4 | 86.9 | 79.7 | 87.3 | 83.8 | 86.2 | 0.7 | 85.0 | +1.2 |
| 75. | 80.5 | 78.9 | 76.0 | 80.5 | 76.0 | 78.8 | 0.7 | 77.2 | +1.6 |
| 85. | 69.1 | 69.5 | 66.5 | 71.4 | 66.3 | 69.2 | 0.8 | 68.4 | +0.8 |
| 95. | 62.9 | 53.6 | 57.9 | 56.1 | 52.8 | 55.4 | 1.6 | 54.8 | +0.6 |
| 100. | . . . . | . . . . | 37.4 | . . . . | . . . . | 37.4 | 0.9 | 37.4 | 0.0 |

comparatively small number of observations, it seems difficult to decide whether the apparently greater brilliancy towards the edge along the equatorial diameter is real, or is due to errors of observation. Column 7 gives the mean of all the measurements taken, and column 8 the probable error of this mean.

If the sun had no atmosphere, its disk as seen from a distance would appear uniformly bright, since the light emitted by one square metre in any given direction is inversely as the cosine of the angle of emission, while, owing to foreshortening, its apparent area is proportional to the cosine of the same angle. Let us next suppose it surrounded by a homogeneous atmosphere not perfectly transparent. Evidently the absorption will depend on the distance which the light has to pass through it, and will be greatest at the edges, and least at the centre; or the disk will appear brightest at the centre and darkest at the exterior, as is actually the case. To determine the law of this variation, let the radius of the disk equal unity, $x$ the apparent distance of any point from the centre, $h$ the height of the atmosphere, $b$ the brightness of any portion of the disk were there no atmosphere, $a$ the proportion of light which would traverse a thickness of the atmosphere equal to unity, or to the sun's radius. Call $v$ also the distance the light from the point $x$ must traverse before emerging from the solar atmosphere, and $y$ the apparent brightness of the same point. It is readily proved that $v = \sqrt{(1+h)^2 - x^2} - \sqrt{1 - x^2}$, and that $y = ba^v$; therefore,

$$y = ba^{\sqrt{(1+h)^2 - x^2} - \sqrt{1 - x^2}}$$

is the equation which gives the brightness of any point of the sun's disk, assuming that its atmosphere is homogeneous. From any three corresponding values of $x$ and $y$ we can compute $a$, $b$, and $h$. Assuming from the above observations $y = 1$ for $x = 0$, $y = .782$ for $x = .75$, and $y = .374$ for $x = 1$, and taking logarithms, we deduce the three equations of conditions: —

$$\begin{aligned} 0 &= \log b + h \log a\,; \\ -.1068 &= \log b + (\sqrt{(1+h)^2 - .5625} - .6614) \log a\,; \\ -.4271 &= \log b + (\sqrt{2h + h^2}) \log a. \end{aligned}$$

Subtracting these equations, we eliminate $b$; and dividing one of the resultant equations by the other, eliminates $a$. We thus deduce the equation: —

$$\sqrt{.4375 + 2h + h^2} - .25\sqrt{2h + h^2} - .75h - .6614 = 0.$$

To solve this equation, its first member was placed equal to $m$, and various values of $h$ substituted; a curve was then constructed with $m$ and $h$ as coördinates, and a few trials readily gave the value of $h$ corresponding to $m = 0$. This affords an easy means of solving many equations not readily treated by the usual methods. The value of $h$ thus found was a little less than unity. Substituting $h = 1$ gives $\log a = -.5835$, $a = .2609$, $\log b = .5835$, and $b = 3.833$. Or, if the effect of the solar atmosphere resembles that of a homogeneous atmosphere, its height must equal the radius of the sun, and its opacity be such that the light in the centre is only .26 of what it would be were the atmosphere removed; or the sun's brightness in the latter case would be throughout 3.8 times its present brightness at the centre. Substituting these values of $a$, $b$, and $h$ in our first equation, gives

$$\log y = .5835 - .5835\,(\sqrt{4 - x^2} - \sqrt{1 - x^2}),$$

in which, by substituting various values of $x$, we deduce the corresponding values of $y$, the light at various points of the sun's disk. In Table I., the column headed Theor. gives the amount of light computed by this formula, and the last column the differences from the mean observations, *M.* Three other theoretical values were computed for these points, but those given in the table were retained as agreeing most nearly with observation. From these it appeared that a considerable variation in $h$ did not alter the amount of light very materially, that a diminutive change of $h$ of one-tenth increased the light between $x = .6$ and $x = .9$ only half a per cent, and for other values of $x$ altered $y$ still less. Moreover, the differences in the last column of the table are evidently too regular to be due to accidental error, but rather show a real variation from theory, due to the fact that the atmosphere is not really homogeneous. We might assume that the law of the density is the same as that of the earth's atmosphere, or that, the height being taken in arithmetical progression, the densities will vary geometrically. But this leads to an equation which cannot be integrated, and, moreover, cannot be correct in fact, since it assumes that the temperature is uniform throughout. The great heat near the surface, by expanding the atmosphere in contact with it, diminishes its density, thus rendering it more nearly homogeneous than the above law would require; this effect is, however, counteracted by the tendency of the heavier gases to descend.

It is a matter of interest to know not merely how much light is cut off by the atmosphere at the centre of the sun's disk, but also how much the whole light of the sun will be reduced by the same cause.

Suppose the curve constructed with coördinates equal to $x$ and $y$ of the preceding table, and that a solid of revolution is generated by revolving it around the axis of $Y$: evidently, the volume of this solid will represent the total amount of light received by the observer from the whole of the sun's disk, and the volume of the circumscribing cylinder will equal that which would be received if the disk throughout had the same brightness as at the centre. The ratio of these two quantities is, however, obtainable by Simpson's formula, and gives the result 82.6, or the light is about five-sixths of what it would be if the disk had the same brightness at the edges as at the centre. Now, as shown above, the light at the centre is reduced by the atmosphere to 26.1 per cent. Hence the total reduction of the whole surface is $.261 \times .826 = .216$. And, since the light is reduced in every direction by the same amount, we may say that the sun would give out 4.64 times as much light if its atmosphere were removed.

The results of this paper may therefore be summed up as follows. The light of the various parts of the sun's disk is measured by the modification of the Bunsen photometer here employed, and given in the accompanying table, with a probable error not exceeding one per cent except close to the edge. The light at the edge is about .4 of that at the centre. The variations in brightness are nearly those which would be produced by a homogeneous atmosphere of height equal to the sun's radius, and opacity such that only 26 per cent of the light is transmitted. There appears to be a slightly different distribution of the light along the polar, from that along the equatorial, diameter. If the atmosphere were removed, the brightness of the sun's disk would be uniform, and 3.83 times that of the centre of the disk at present. Moreover, the total amount of light would be increased 4.64 times.

## VI. — TESTS OF A MAGNETO-ELECTRIC MACHINE.

By E. C. Pickering and D. P. Strange.

The rapidly increasing use of magneto-electric machines as a source of electricity renders accurate tests of the comparative advantages of the various forms and exact measurements of the currents generated under varying conditions very desirable. The machine employed in the following experiments was made by Mr. M. G. Farmer, and consists of a large electro-magnet wound with four coils soldered together